DRYING OF STEEL TEEMING LADLE MONOLITHIC LININGS

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With the use of unformed refractory compounds with an increased moisture content (up to 13%) for preparation of steel teeming ladle linings the role of drying increases significantly, especially if it is taken into consideration that the drying time is tens of times longer than preparation of the lining.

The equipment for drying of ladle lining existing in the majority of steel plants does not provide uniform delivery of heat to the lining surface. Sufficient attention is also not devoted to organization of rational movement of the heat carrier within the ladle. As the result of this together with a long drying time there are a significant over consumption of fuel and a low ladle lining quality after drying (cracks, bulgings). As has been mentioned [1], under the action of temperature and pressure gradients a large portion of the moisture penetrates into the depth of the lining and under the action of gravitational forces drops to its lower portion.

Investigations of existing drying methods made in the open hearth shops of Magnitogorsk and Nizhnii Tagil Metallurgial Combines and also the results of work presented in [2, 3] make it possible to conclude that the greatest concentration of moisture is formed in the lower and heaviest portion of the ladle at the joint of the walls and bottom.

Figure 1 shows curves of the change in temperature at points 1-3 on the boundary of the monolithic and reinforcing layers in drying of a 300-ton steel teeming ladle of No. 1 Open Hearth Shop at Magnitogorsk Metallurgical Combine. The lining was dried with the tube-in-tube type burner used in the combine with a lined cover. The natural gas consumption for drying was 30 m^3/h. The lining was preated from silica concrete and the thickness of the upper portion was 150 and of the lower 180-200 mm.

From Fig. 1 it may be seen that the temperature at points 2 and 3 exceeded 100°C after 8-12 h, which with a sufficient degree of approximation accuracy may be assumed to be the end of drying. The temperature at point 1 reached 100°C after 21-22 h from the start of drying.

Temperature measurements within the ladle on the working surface of the lining with an optical pyrometer and a Chromel–Alumel thermcouple showed that it changes insignificantly on the height of the ladle. The temperature near the bottom was 1250, in the center portion of the ladle 1100, and at the top under the cover 1050°C.

Table 1 shows the results of analysis of the gas combustion products within the ladle on its height, which are an indication of poor combustion of the flame, significant chemical undercombustion, and, as a result, overconsumption of fuel.

TABLE 1

Point of measurement	Wt. % in the combustion products		
	CO_2	O_2	CO
Close to the bottom	5,0	—	5,2
	5,2	—	3,0
	5,0	—	3,2
Center of height of the ladle	6,6	6,0	0,4
	10,6	1,0	1,2
Top of the ladle	10,0	2,2	0,8
	9,0	3,4	1,0

Eastern Refractory Institute. Nizhnii Tagil Metallurgical Combine. Translated from Ogneupory, No. 11, pp. 3-6, November, 1988.

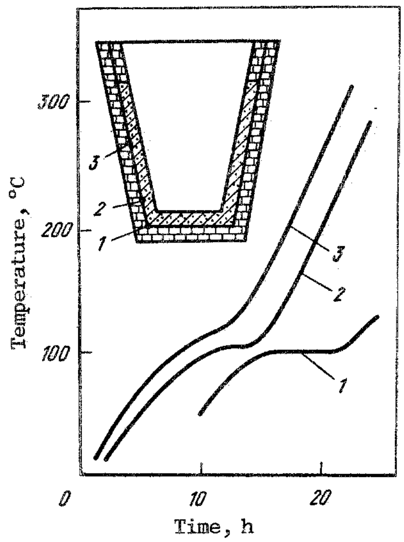

Fig. 1. Change in temperature at points 1-3 on the boundary of the monolithic and reinforcing layers in drying of a 300-ton steel teeming ladle: 1) joint of the walls and bottom; 2) 400 mm above point 1; 3) center of the ladle.

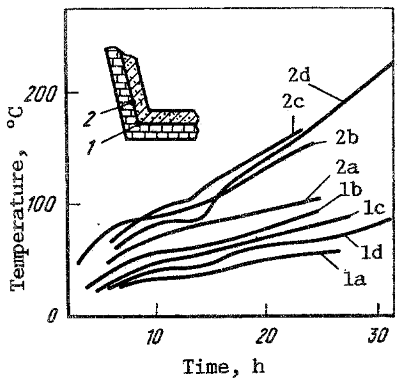

Fig. 2. Change in temperature at points 1 and 2 in drying of 230-ton ladles with different gas consumptions and drying times: a) gas consumption 200 m^3/h, drying time 19.5 h; b) 300 m^3/h, 16 h; c) 450 m^3/h, 23 h; d) 470 m^3/h, 32 h.

Similar investigations of the drying of the monolithic linings of 230-ton steel teeming ladles were made in No. 1 Open Hearth Shop of Nizhnii Tagil Metallurgical Combine. The investigation results are shown in Fig. 2. The temperature measurements were made with two thermocouples. The junction of one of them was placed at the joint of the wall and the bottom (point 1) and the junction of the other 400 mm higher (point 2). The measurements were made with different consumptions of natural gas and drying times. The ladles were dried without a cover.

From Fig. 2 it may be seen that in not one of the four tests did the temperature at point 1 increase to 100°C and at point 2 with a fuel consumption of 200 m^3/h it also did not reach 100°C in 19.5 h but in the remaining tests it exceeded 100°C 11-15 h after the start of drying.

As the result of the investigations it may be concluded that the burners used at Magnitogorsk and Nizhnii Tagil Metallurgical Combines do not provide normal drying of steel teeming ladle monolithic linings even with a significant increase in drying time and fuel consumption.

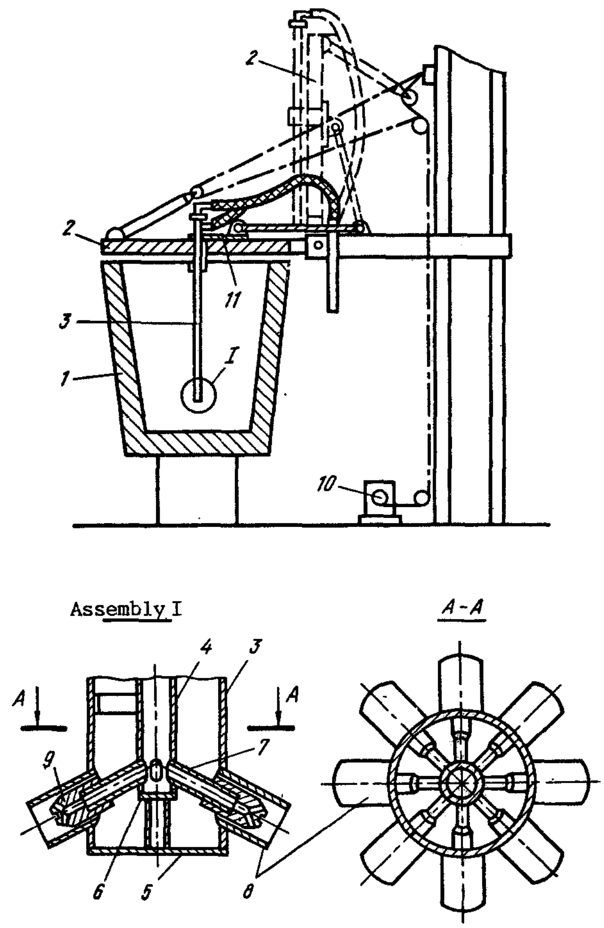

Fig. 3. Equipment for drying steel-teeming ladles.

A burner design (Fig. 3) was developed for the purpose of providing uniform heating of the ladle lining, correct combustion of the flame with a sufficiently broad range of control of the gas–air ratio, drying to any specified cycle, fuel economy, and a reduction in drying time.

In the lined ladle 1 with the cover 2 are coaxially placed the air 3 and gas 4 pipes, the ends of which are covered by the end plates 5 and 6. On the perimeter of the pipes there are uniformly place outlet fittings consisting of gas 7 and air 8 tubes and gas nozzles 9 with holes. The nozzles are placed at an angle to the bottom of the ladle.

As the result of this design of burner thermal shocks in the center portion of the bottom of the ladle are eliminated and the combustion products are uniformly distributed on the periphery of the bottom, which provides the same thermal load over its whole area. The ladle walls, the lining of which is thinner, are heated by the combustion products rising from the lower portion of the ladle and having a lower temperature. This eliminates overheating of the walls.

After placing the ladle on the drying stand the burner, which is hinged connected to the cover, is lowered into the cavity of the ladle by the electric drive 10 (Fig. 3) and at the same time it moves in a plane-parallel direction relative to the latter. To provide placement and removal of the burner from the cavity of the ladle the cover is equipped with the slide 11 located in guides with the pipes 3 and 4 of the burner hinged fastened to it. In raising of the cover into the vertical position the slide moves on the guides to the edge of the cover farthest from the axis of rotation to prevent contact of the lower portion of the pipes against the edge of the ladle.

The proposed design makes it possible to significantly reduce the labor cost for preparation of the burner for operation and to eliminate the requirement for additional production area.

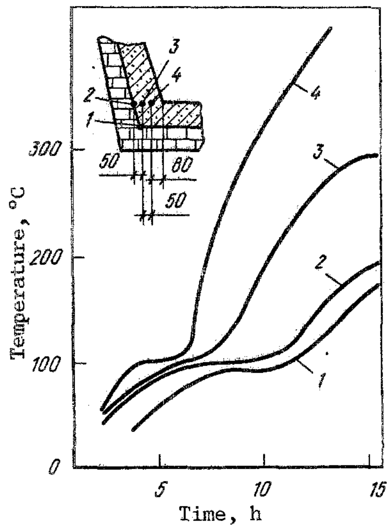

Fig. 4. Change in temperature at points 1 and 2 on the boundary of the monolithic and reinforcing layers and at points 3 and 4 in the thickness of the monolithic layer of the lining in crying of a 230-ton ladle with the burner developed.

The burner developed has been introduced into No. 1 Open Hearth Shop of Nizhnii Tagil Metallurgical Combine.

During setting up and development of drying methods for monolithic linings, temperature fields across the thickness of the lining were investigated (Fig. 4). Thermocouples were installed at the whole thickness of the wall lining in its lower portion and at depths of 130 and 80 mm from the surface (points 2-4, respectively), and also between the monolithic and reinforcing layers at the joint of the wall and bottom (point 1).

As may be seen from Fig. 4, drying of the ladle is completed in 11 h since the temperature at the most distant point 1 starts to rise above 100°C during this time. The time intervals during which drying of the ladle occurs at points 2-4 is 5, 6, and 9 h, respectively.

Similar results were obtained in conducting investigations on six existing ladles.

The natural gas consumption for a single drying was an average of 2000 m^3 in place of 5000 m^3 using the drying method previously used in the shop (12 h with a gas consumption of 400-440 m^3/h).

Visual inspection of the lining surface after drying showed that it is smooth without cracks and bulges.

The use of the burner provided a 3.5% increase in lining life according to the data of Nizhnii Tagil Metallurgical Combine (the lining life of the ladles of No. 1 Open Hearth Shop was 11-15 heats). The insignificant increase in life may be explained by the significant variation in temperature during teeming of steel and after it, which has a negative influence on life.

CONCLUSIONS

Investigations were made of existing methods of drying of the monolithic linings of the steel teeming ladles of the open hearth shops of Nizhnii Tagil and Magnitogorsk Metallurgical Combines and their shortcomings were revealed.

A burner was developed providing more uniform heating of the ladle lining and permitting drying using any specified cycle.

A significant saving in fuel and a reduction in drying time were obtained.

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SCIENTIFIC RESEARCH

EVALUATION OF THE SERVICE CHARACTERISTICS OF THE EXPERIMENTAL BATCHES OF INDUCTION-MELTED ELECTRICAL-ENGINEERING PERICLASE

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This paper presents the results of our experimental studies on the service characteristics of electrical-engineering periclase that was obtained by induction melting in a cold crucible (IMCC).

The previous studes showed that it is promising to use the clean (uncontaminating) method of IMCC for obtaining high quality electrical engineering periclase (in conjunction with its heat treatment [1] and antihydration treatment [2]).

In order to determine the service properties, we took three experimental batches of electrical engineering periclase, viz., No. 1 – periclase containing Ga_2O_3 addition with subsequent high-temperature firing; No. 2 – periclase heat treated after melting; and No. 3 – unheat-treated periclase that was treated with the GKZh-94 silicone (organosilicon) liquid for protecting it against hydration during its storage. Preparation of the periclase powders obtained by IMCC was carried out according to the procedure described elsewhere [1].

Microstructural studies carried out on periclase according to the methods of x-ray diffraction and microscopic analysis showed that periclase of the Nos. 1 and 2 batches consists of colorless or pale yellow grains. The content of the impurities present in the form of simple and complex oxides is insignificant. CaO is virtually absent (<0.01 %). SiO_2 is present in the form of cristobalite, enstatite ($MgSiO_3$), wollastonide ($CaSiO_3$), and forsterite (Mg_2SiO_4).

The cristobalite content amounts to 1.0-1.5% (it is somewhat lower in the No. 2 batch) and the Fe_2O_3 and Al_2O_3 contents amount to 0.005 and 0.048%, respectively. The Ga_2O_3 addi-

TABLE 1. Granulometric Composition of the Experimental Batches of Periclase Obtained by IMCC

Periclase	Residue on sieve, %, with the sieve number						
	05	04	025	016	0063	004	<004
Batch							
№ 1	0,7	9,2	27,1	11,9	20,0	11,3	19,8
№ 2	0,4	5,7	29,5	11,5	20,3	12,1	20,5
№ 3	1,2	12,0	27,3	10,7	38,3	6,9	3,6
According to GOST 13236—83	—	<2	>30	—	>30	<8	<4
PPE-1M	—	1,2	29,8	32,4	31,7	3,3	1,6
'Dinaterm'	—	—	33,2	30,1	30,5	5	1,2

Translated from Ogneupory, No. 11, pp. 6-8, November, 1988.